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ABSTRACT

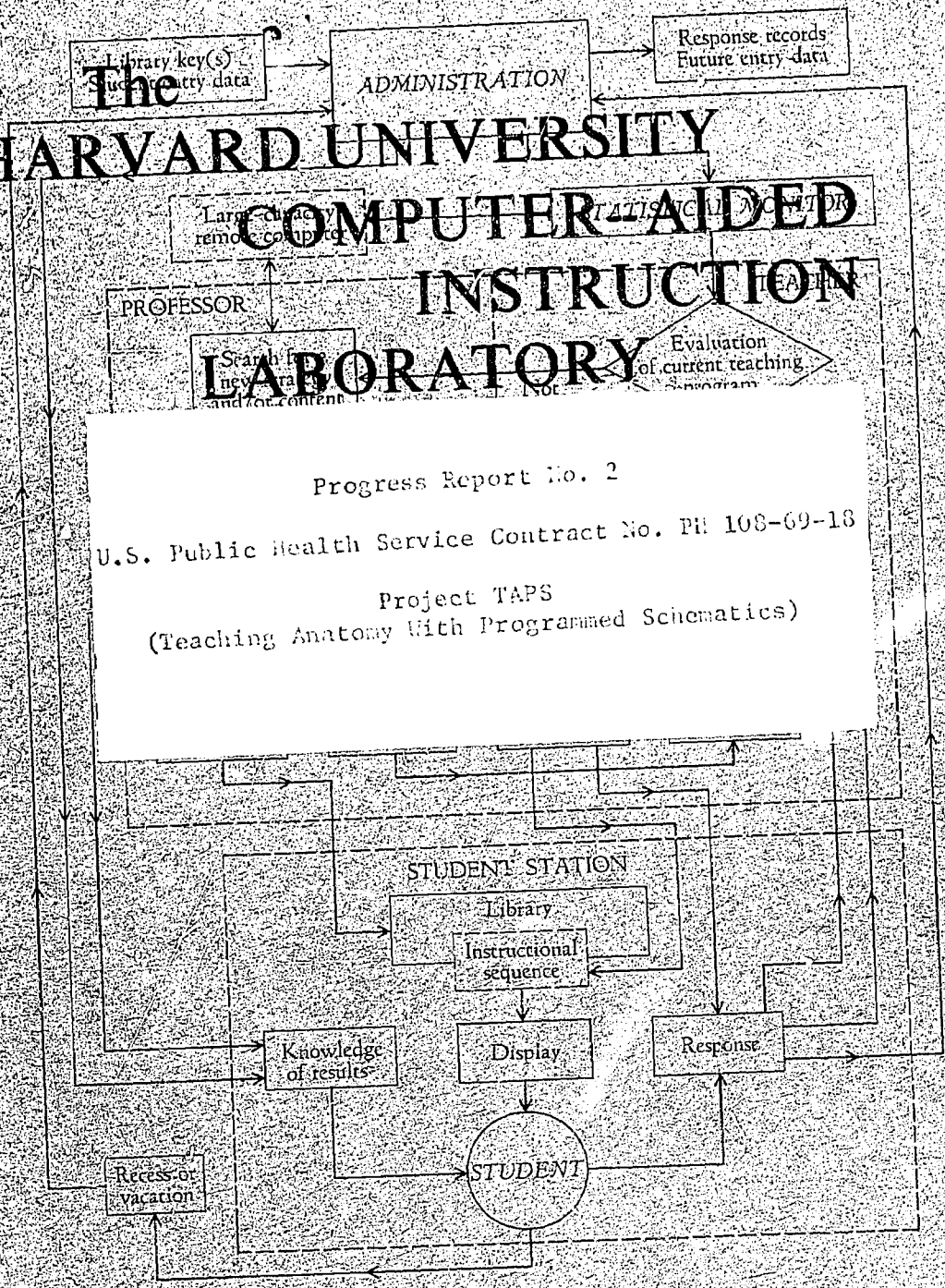
TRIGEM, a computer-assisted instruction (CAI) course developed as a part of Project TAPS (Teaching Anatomy with Programed Schematics) is designed to teach the anatomy of the maxillary division of the trigeminal nerve. This course is currently operational on the Harvard CAI System which uses an IBM S 360/Model 65 as the central processor, either teletypes or IBM 1050 consoles as the student interface, and CAILAN as the interactive language. The students also use printed visual aids. A pilot study and a second study are described. The studies were designed to compare the effectiveness of two different ways of presenting visual information while the student is learning and the effect of the student's attitude toward CAI on his rate of learning. An abstract of the TRIGEM course is appended. The report is supplemented by data tables. (Author/JY)

The HARVARD UNIVERSITY COMPUTER-AIDED INSTRUCTION LABORATORY

Progress Report No. 2

U.S. Public Health Service Contract No. PH 108-69-18

Project TAPS
(Teaching Anatomy With Programmed Schematics)



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Project TAPS
(Teaching Anatomy With Programmed Schematics)

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May 1, 1970

Principal Investigator:
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Abstract

This report details the status of Project TAPS (Teaching Anatomy with Programmed Schematics) and summarizes data obtained from two studies. This project is being supported by the U. S. Public Health Service and is being conducted by the Harvard Computer-Aided Instruction Laboratory in cooperation with Harvard Dental and Medical Schools and Tufts University Dental School.

More specifically, this report describes TRIGEM, the CAI course developed as a part of Project TAPS to teach the anatomy of the maxillary division of the trigeminal nerve. This course is currently operational on the Harvard CAI System which uses an IBM S 360/Model 65 as the central processor, either teletypes or IBM 1050 consoles as the student interface, and CAILAN as the interactive language which operates under OS. The students also use printed visual aids.

A pilot study and a second study are described. The studies were designed to compare the effectiveness of two different ways of presenting visual information while the student is learning. An abstract of the CAI course TRIGEM is included at the end of this report.

TAPS [1]

This project was proposed as an investigation into the relative effectiveness of two different forms of perceptual support for instruction. More specifically, it is concerned with improving the learning and retention of anatomical information through the programmed presentation of perceptual aids to verbal learning in an interactive mode.

The two types of perceptual supports were schemata and representational diagrams. Each was used to support a programmed dialogue presented by a computer to a student at a teletype. The instructional program, called TRIGEM, was designed to teach terminology and concepts. (see Program Abstract, p. 28)

The research aim was to compare two conditions of instruction in a section of the anatomy course. The comparison of two different ways of encoding perceptual information is interesting in that the novel way of providing perceptual information could be used extensively if found superior.

TRIGEM

The CAI course TRIGEM is based on programmed instruction materials which have been adapted for presentation by the IBM S 360/65 instructional system at Harvard University (Fig. 1). The course can be accessed by either a standard teletype or an IBM 1050 terminal connected to a 103A2 dataset. With the cooperation of Dr. William M. Feagans at Tufts University, five teletypes were installed in a trailer adjacent to the school area and connected by telephone lines to the Harvard system.

TRIGEM consists of two almost identical programs, PF and PD, which differ only in the graphic representations used. Program PF uses two representational drawings (Fig. 2) taken from Gray's Anatomy. Program PD uses a schematic diagram and identification key (Figs. 3 and 4).

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[1] An acronym for Teaching Anatomy with Programmed Schematics.

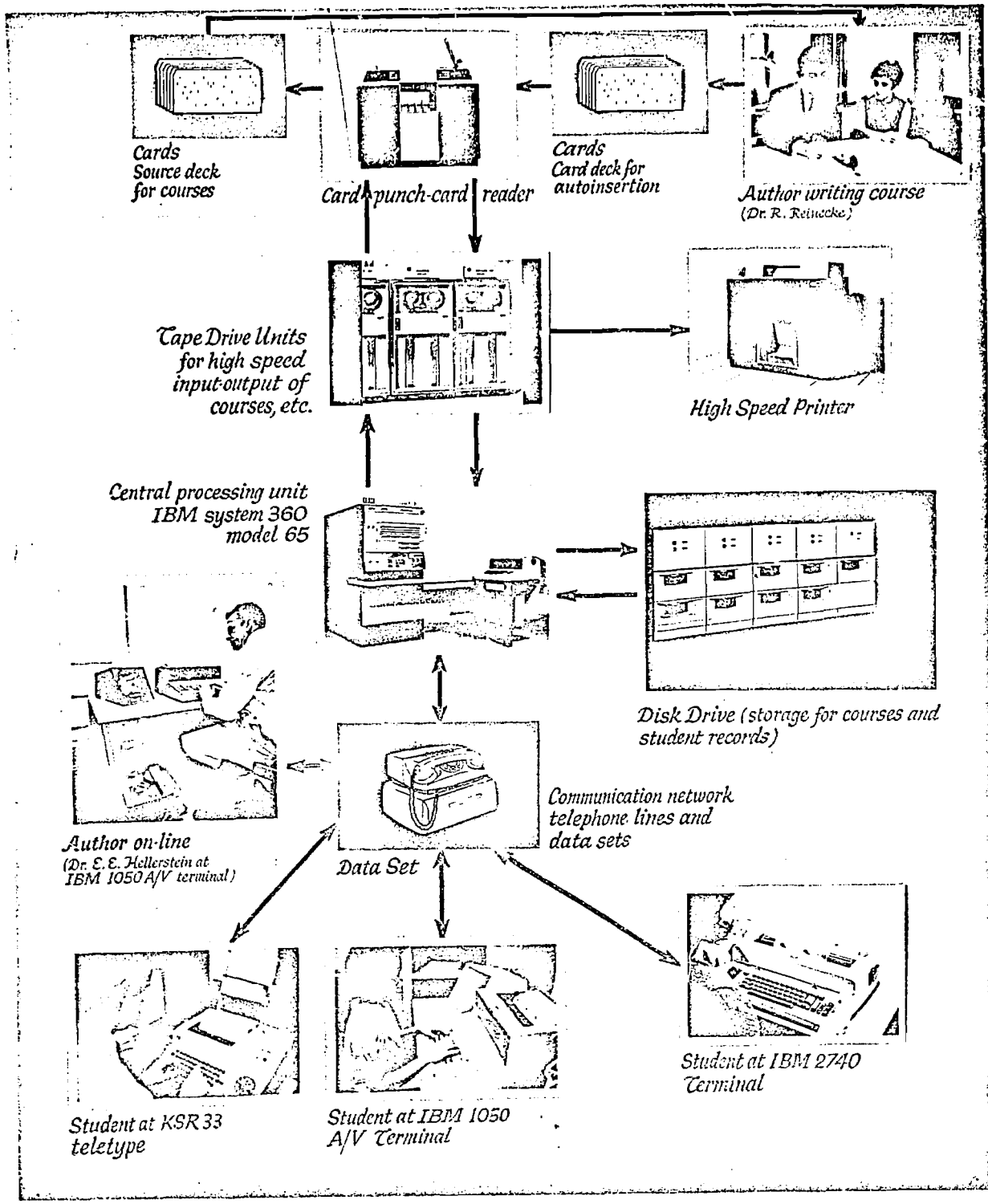


Fig. 1. Harvard University computer-based interactive instructional system.

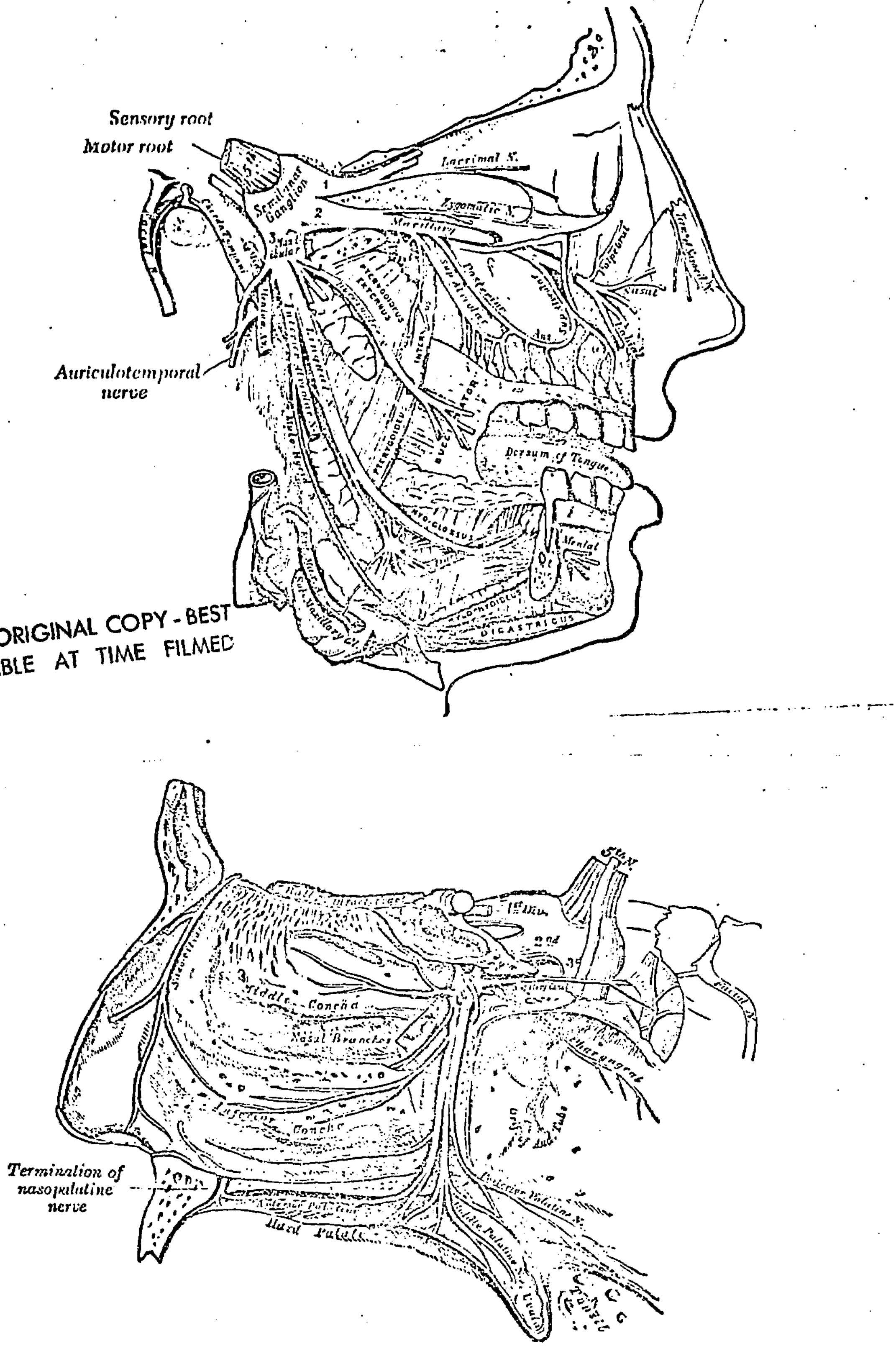


Fig. 2. The two representational diagrams used in Program PD of the CAI course TRIGEM. Reproduced for research purposes with the permission of the publishers of Gray's Anatomy.

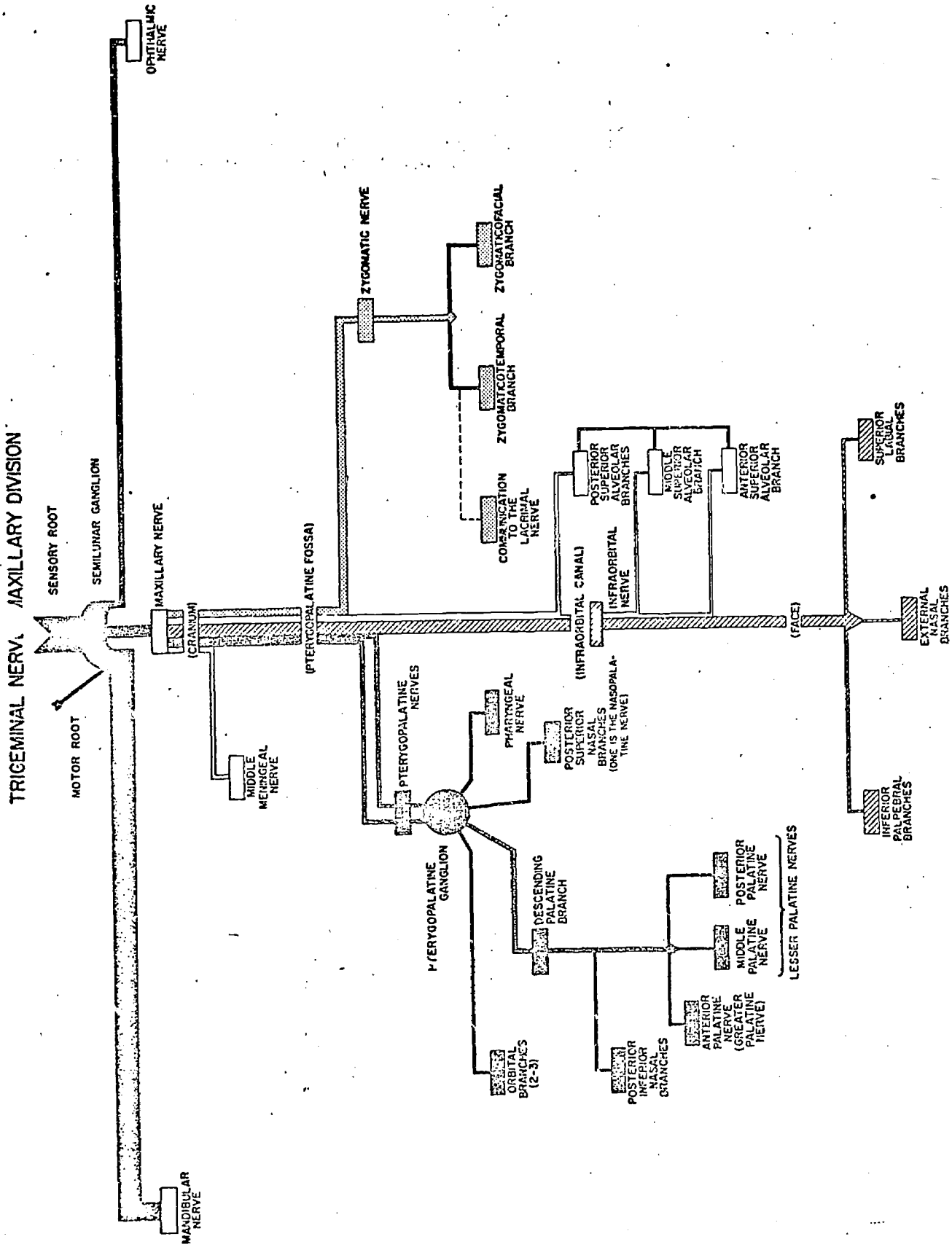
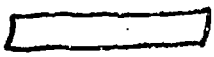
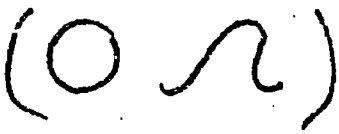
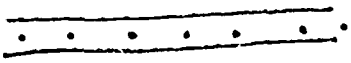
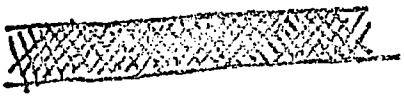
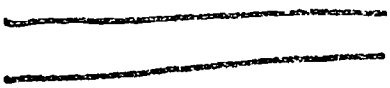
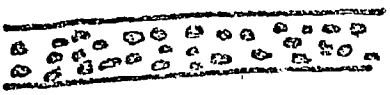


Fig. 3. The schematic diagram used in Program PF of the CAI course TRIGEM.

Symbol	What The Symbol Represents
	nerve root
 maxillary nerve	nerve name
rounded forms 	ganglion
	middle meningeal nerve
	pterygopalatine nerve
	facial branches
	superior alveolar branches
	zygomatic nerve

Note: Breaks in the center of Fig. 3 contain the names of the regions through which the maxillary passes; their names appear in parentheses.

Fig. 4. The identification key used with the schematic diagram shown in Fig. 3.

These materials were dry-mounted on heavy cardboard and made available to students at the terminal. Each program requires approximately 1 and 1/4 hours of student time, depending on response rate.

Pilot Study[2]

Design

For the purpose of the project, the design proposed made use of four groups of students, drawn at random from a first-year class at a dental school. Each group was to take the two parts of the course in a different sequence: Group A, PD (see Fig. 2) twice in succession; Group B, PD first and then PF (see Fig. 3); Group C, PF first and then PD; and Group D, PF twice in succession. However, in this first study it was possible to secure only two groups -- one taking the program with the schematic diagram (Fig. 3) and the other with the traditional material (Fig. 2).

All students were asked to fill out an attitude questionnaire and take a written test on knowledge of content, both before and after the CAI course. The attitude questionnaire was designed to determine a student's attitude toward CAI before and after his use of it as a participant in this study.[3] The questionnaire consists of 15 statements, to which the student responds "yes," "no," or "maybe," to indicate his degree of agreement. The questionnaire requires about 1 minute to complete; its pre- and posttest forms are identical except for the verb form used, i.e., future and past tense (see Figs. 5 and 6).

Students are also given a test question booklet and an answer booklet to determine their knowledge of the subject matter presented before

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[2] Spring-semester students at Tufts Dental School were used.

[3] This questionnaire was originally developed by Professor Timothy Smith, formerly of Florida State University, Tallahassee, Florida.

Scale of Attitudes Toward Computers

Name _____ Date _____

School or Center _____

1.	I would learn more quickly by using the computer.	Yes___Maybe___No___
2.	I could work at my own speed on the computer.	Yes___Maybe___No___
3.	It would be interesting to work by computer.	Yes___Maybe___No___
4.	It would be easier to learn by computer than with a teacher.	Yes___Maybe___No___
5.	I would like sitting and working alone.	Yes___Maybe___No___
6.	I think students learn better by computer than with a teacher.	Yes___Maybe___No___
7.	It would be easier to learn by computer than with films and slides.	Yes___Maybe___No___
8.	I think students learn better by computer than with a book.	Yes___Maybe___No___
9.	I have used a typewriter.	Yes___A bit___No___
10.	I'm afraid I could not learn how to use a computer very well.	Yes___Maybe___No___
11.	I would need a teacher as I work on the computer.	Yes___Maybe___No___
12.	I would like to use a computer.	Yes___Maybe___No___
13.	Using a computer would be like having a friendly teacher.	Yes___Maybe___No___
14.	Learning by computer would go too fast.	Yes___Maybe___No___
15.	I would not mind if I missed a question while working on a computer since no one would be watching me.	Yes___Maybe___No___

HCAI/Pre-/4/69

Fig. 5. CAI Attitude Scale, pretest form.

Scale of Attitudes Toward Computers

Name _____ Date _____

School or Center _____

1.	I learned more quickly by using the computer.	Yes___Maybe___No___
2.	I worked at my own speed on the computer.	Yes___Maybe___No___
3.	It was interesting to work by computer.	Yes___Maybe___No___
4.	It was easier to learn by computer than in a class.	Yes___Maybe___No___
5.	I liked sitting and working alone.	Yes___Maybe___No___
6.	I think students learn better by computer than with a teacher.	Yes___Maybe___No___
7.	It was easier to learn by computer than with films and slides.	Yes___Maybe___No___
8.	I think students learn better by computer than with a book.	Yes___Maybe___No___
9.	I have used a typewriter.	Yes___A bit___No___
10.	I'm afraid I did not learn how to use a computer very well.	Yes___Maybe___No___
11.	I need a teacher as I work on the computer.	Yes___Maybe___No___
12.	I liked using a computer.	Yes___Maybe___No___
13.	Using a computer is like having a friendly teacher.	Yes___Maybe___No___
14.	Learning by computer went too fast.	Yes___Maybe___No___
15.	I did not care if I missed a question while working by computer since no one was watching me.	Yes___Maybe___No___

HCAI/Post-/4/69

Fig. 6. CAI Attitude Scale, posttest form.

they start the course. Fig. 7 shows the first page of the booklet with test questions and Fig. 8, the corresponding page of the answer booklet. The test booklet contains the questions only, and all answers are written in the separate answer booklet. This test measures the behavioral objectives of the course; consequently, it is a criterion-referenced test and yields a fairly thorough measure of the student's knowledge of the structure, function, and terminology of the trigeminal nerve. There is no difference in pre- and posttest forms; both contain 45 items for Part 1, 28 for Part 2, 21 for Part 3, and 24 relating to the configuration.

Since the only difference between the PD and PF programs lies in the learning aids they use, it is assumed that any significant difference in group average posttest scores on this test is due to a difference in effectiveness of those aids.

Materials

The PD and PF programs are each divided into four sections. The first section of each program provides a description of nerves in general and introduces the student to the trigeminal nerve, of which the maxillary division, the subject matter of TRIGEM, is a part.

The second section of each program teaches the branches, or configurations, of the maxillary division. The student first sketches the configurations of the several component structures of the nerve and then combines them to achieve knowledge of the entire structure.

The third section teaches the names of the nerves and the areas supplied by them. In order to aid the student's understanding and recall of this material, an analysis of each term's Latin components is given, together with the English meanings of these components.

TEST - Part 1

Fill in the answers to the following questions in the appropriate space on the ANSWER SHEET!!

DO NOT WRITE IN THIS BOOKLET!

1. Write the names of the divisions of the trigeminal nerve. Put the name of the largest division on the first line, the second largest division on the second line, and the smallest division on the third line.

2. Write the names of all the branches and branches of branches of the maxillary nerve in the order they separate. Include the name which the maxillary nerve attains after entering the orbit. In other words, write the name of the first branch in the cranium. Below the name of the first branch write the names of all its branches in order. Then do the same for all other branches of the maxillary nerve in order. You may need more or less space than is provided for question 2 on the answer sheet.

3. In the column titled "3. Area Supplied" on the answer sheet list the general area supplied by each nerve or branch you named for question 2. List the area supplied in the same row in which the nerve is named.

Fig. 7. Page 1 of the test question booklet. Pre- and posttest forms are identical.

ANSWER SHEET

Part 1

Name _____ I D _____

1. _____

3. Area Supplied

2. Nerve Names

Fig. 8. Page 1 of answer booklet. Pre- and posttest forms are identical.

The fourth and last section of each program teaches the regions through which each of the branches of the maxillary division passes. As in the third section, terms are broken down into their Latin components.

Both programs are of equal length, 111 frames. There are two basic frame types, denoted by the abbreviations RD ("read") and QU ("Question").[4] An RD frame requires the student to simply read a paragraph (Fig. 9). When he is ready to continue he presses the EOB (End of Block) key, which signals the system to proceed with the course. Some RD frames require the student to draw a sketch of some region of the trigeminal nerve (Fig. 10). A booklet is provided for this purpose; however, there are electronic sketch pads that could be put on-line if that were wanted and could be afforded. The booklet used in this study contains blank pages for the drawings, alternating with pages on which the correct configurations are printed. The student draws his sketch on the designated page of the booklet and then turns the page to find the correct answer. When he is satisfied that he knows the configuration, he keys EOB and the computer proceeds to the next frame.

The second basic frame type is the QU frame, which requires the student to type information as a part of his reponse. This information may be to fill in a blank or answer a direct question. If the answer is correct, the computer responds by typing CORRECT and proceeding to the next frame (Fig. 11). If the answer is correct but misspelled, the computer responds as shown in Figure 12. This response has been designed

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[4] These refer to the "op codes" in CAILAN, the CAI language used on the Harvard CAI System.

COMPUTER: NERVES ARE LONG WHITISH STRINGS OF CELL BODIES AND THEIR "APPENDAGES" WHICH CONDUCT MESSAGES FROM ONE PART OF THE ANATOMY TO ANOTHER. THE NERVE APPENDAGES ARE THE LONG PART WE USUALLY REFER TO WHEN WE SPEAK OF A NERVE.
STUDENT (when ready to proceed to next frame): (eob)

Fig. 9. A typical RD frame from the CAI course TRIGEM, Part 1, "general properties of nerves."

COMPUTER: NOW, WITHOUT LOOKING AT THE DIAGRAM, SKETCH THE DIAGRAMMATIC CONFIGURATION FOR ALL THE PTERYGO-PALATINE NERVES. DRAW ON PAGE 11 OF THE BOOKLET, AND THEN COMPARE YOUR DRAWING TO THE ONE SHOWN ON PAGE 12 OF THE BOOKLET.
STUDENT (after drawing the configuration and checking it): (eob)

Fig. 10. A typical RD frame from the CAI course TRIGEM requiring the student to draw a sketch, Part 2, "branches and configurations."

COMPUTER: LOOK AT THE DIAGRAM. THE PTERYGOPALATINE NERVES APPEAR TO FORM THE ..... GANGLION. ACTUALLY THEY PASS RIGHT THROUGH THE GANGLION AND DO NOT FORM IT.
STUDENT: PTERYGOPALATINE (eob)
C: CORRECT

Fig. 11. A typical QU frame correctly answered by the student.

COMPUTER: ONE BRANCH OF THE POSTERIOR SUPERIOR NASAL BRANCHES IS LONGER THAN THE REST. THIS BRANCH IS NAMED ON THE DIAGRAM AND IS THE ..... .
STUDENT: NASOPALITINE (eob)
COMPUTER: RIGHT--THE NASOPALATINE NERVE.

Fig. 12. A typical QU frame to which student gives a correct but misspelled answer. Note that the correct spelling is provided but he doesn't have to spell it correctly. This is the author's decision as a style of teaching.

COMPUTER: ONE BRANCH OF THE POSTERIOR SUPERIOR NASAL BRANCHES IS LONGER THAN THE REST. THIS BRANCH IS NAMED ON THE DIAGRAM AND IS THE ..... .
STUDENT: PHARYNGEAL (eob)
COMPUTER: INCORRECT. THE CORRECT ANSWER IS NASOPALATINE.

Fig. 13. A typical QU frame incorrectly answered by the student.

to preserve morale by calling the student's attention to his misspelling indirectly, i.e., without actually telling him that he has made an error in spelling. The objective is to teach anatomy. Figure 13 shows one of the computer's responses when the student's answer contains incorrect substantive information. Every time the student's answer is incorrect, the computer tells him he is incorrect, gives him the correct answer, and proceeds to the next frame. This is called non-correction procedure. It does not require him to make the correct response before he goes on.

Pilot Study

In the pilot study which followed the developmental testing of the program, six dental students (3-PD, 3-PF) took the course. No student took the course twice as called for in the original design because it took too long for the time they had available -- about two and one-half hours. All six students completed the pre- and posttest forms of the CAI attitude questionnaire and the achievement test.

Table 1 summarizes the results obtained from the pre- and posttest forms of the achievement test. If we compare the differences between pre- and posttest scores for both groups we find that the PD group who studied with the schematic diagram showed the larger gains on Parts 1, 2, and the total, but the group that studied with the representational diagram achieved bigger gains on Part 3. In general, gains on Part 3 were substantially lower than for the other two parts; however, the possibilities also are lower. The maximum possible score for Part 1 is 45, for Part 2, 28, and for Part 3, 21.

TABLE 1

Scores* made by Six Dental Students on Pre and Post Forms of Achievement Test used in TRIGEM Pilot Study

Form of Program	S No.	Pretest Part No. 1	2	3	Total	Posttest Part No. 1	2	3	Total	Configuration**	Differences Part No. 1	2	3	Total***
PD	1	8	9	8	25	39	28	6	73	23	31	19	-2	48
	3	7	10	5	22	39	26	10	75	23	32	16	5	53
	6	6	8	1	15	32	23	8	63	15	26	15	7	48
Σ											89	50	10	149
PF	2	22	6	5	33	29	16	7	52	18	7	10	2	19
	4	5	7	8	20	33	25	10	68	22	28	18	2	48
	5	4	4	4	12	37	23	15	75	24	33	19	11	63
Σ											68	47	15	124

Key

* A student's score is directly related to number of correct responses.

** In the post form of the achievement test, the student is asked to reproduce the schematic he used during the program. His score depends on the accuracy and detail of his representation, with reference to certain predetermined performance measures.

*** The average difference for the PD group is 49.67; the average for the PF group is 3.16.

Experiment II

The study was repeated in the fall of 1969-70 with Harvard students. Since they had the same time constraints, two groups were used. One, the PD group, had the schematic diagram available during learning and the other, the PF group, had the representational figures from Gray's Anatomy. The teletype terminals were installed in a medical school building for convenient access.

Students

Eighteen students participated and completed all the steps involved. Ten were in the PD or schematic group and eight in the PF or figure group.

Method

In addition to measuring the information learned we measured attitudes. Two different instruments were used (see Figs. 5 and 14). For both, the more favorable the attitude the higher the score. One instrument measured attitude toward CAI (Fig. 5); the other, attitude toward the learning aid and the program (Fig. 14).

The test of knowledge was the same as used in the pilot study.

Results

Cognitive domain, information. The amount learned in terms of mean scores is represented in Table 2 and the bar diagrams shown in Fig. 15.

The data clearly indicate that both groups learned from their experience with CAI, and that the amount learned with the schematic was somewhat more than the amount learned from traditional drawings.

Correlational Analyses

The correlations for the Schematic Diagram Group are given in Table 3; the correlations for the Representational Diagram Group are given in Table 4; and the entire set of correlations is summarized in Fig. 16.

Name: _____ Student No.: _____ School: _____

1. How would you rate this method of learning anatomy relative to the conventional textbook/lecture method in the following areas? Circle one number per line.

	Excellent	Good	Average	Poor	Bad
Effectiveness	1	2	3	4	5
Ease of learning	1	2	3	4	5
Learning speed	1	2	3	4	5
Enjoyment	1	2	3	4	5

2. How do you think the computer method could best be used in the teaching of anatomy? Specifically, should it replace the conventional lecture/textbook/dissection methods, be integrated with them (how?), or not be used at all?

a. replace conventional lecture yes ___ no ___
b. replace textbook yes ___ no ___
c. replace dissection yes ___ no ___
d. not be used at all yes ___ no ___
e. other possibility (describe)

_____

_____

3. How would you assess the effectiveness of the learning aids used in this course with the computer (the schematic diagram or the representational figures or both, if you used both)? Circle one number per line.

	Excellent	Good	Average	Poor	Bad
a. schematic diagram	1	2	3	4	5
b. representational figures	1	2	3	4	5
c. would you use anything else?			yes ___	no ___	

If yes, describe. _____

_____

4. Criticisms, comments, or suggestions for improving the program:

a. text suggestions
b. diagram suggestions
c. computer system suggestions
d. other suggestions

_____

_____

Fig. 14. TRIGEM post-experiment questionnaire designed to measure student attitude toward the course materials -- the learning aid and the program.

TABLE 2

Means of Students on Pre- and Posttest Under the Two CAI Conditions of Learning: PD (Schematic Diagram) and PF (Representational Diagram)

Condition of Learning	No. Ss		Pretest Part No. 1	2	3	Total	Posttest Part No. 1	2	3	Total	Configuration	Differences Part No. 1	2	3	Total
PD	10	Σ	25	9.0	6.0	40	382	228	62	672	222				
		$\bar{X}$	2.5*	0.9*	0.6*	4.0*	38.2*	22.8*	6.2	67.2*	22.2*	35.7*	21.9*	5.6	63.2*
PF	3	Σ	9	0	0	9	210	170	61	441	119				
		$\bar{X}$	1.1	0.	0.	1.1	26.25	21.25	7.625	55.125	14.875	25.15	21.25	7.625	54.025

*These differences favor the PD or experimental condition.

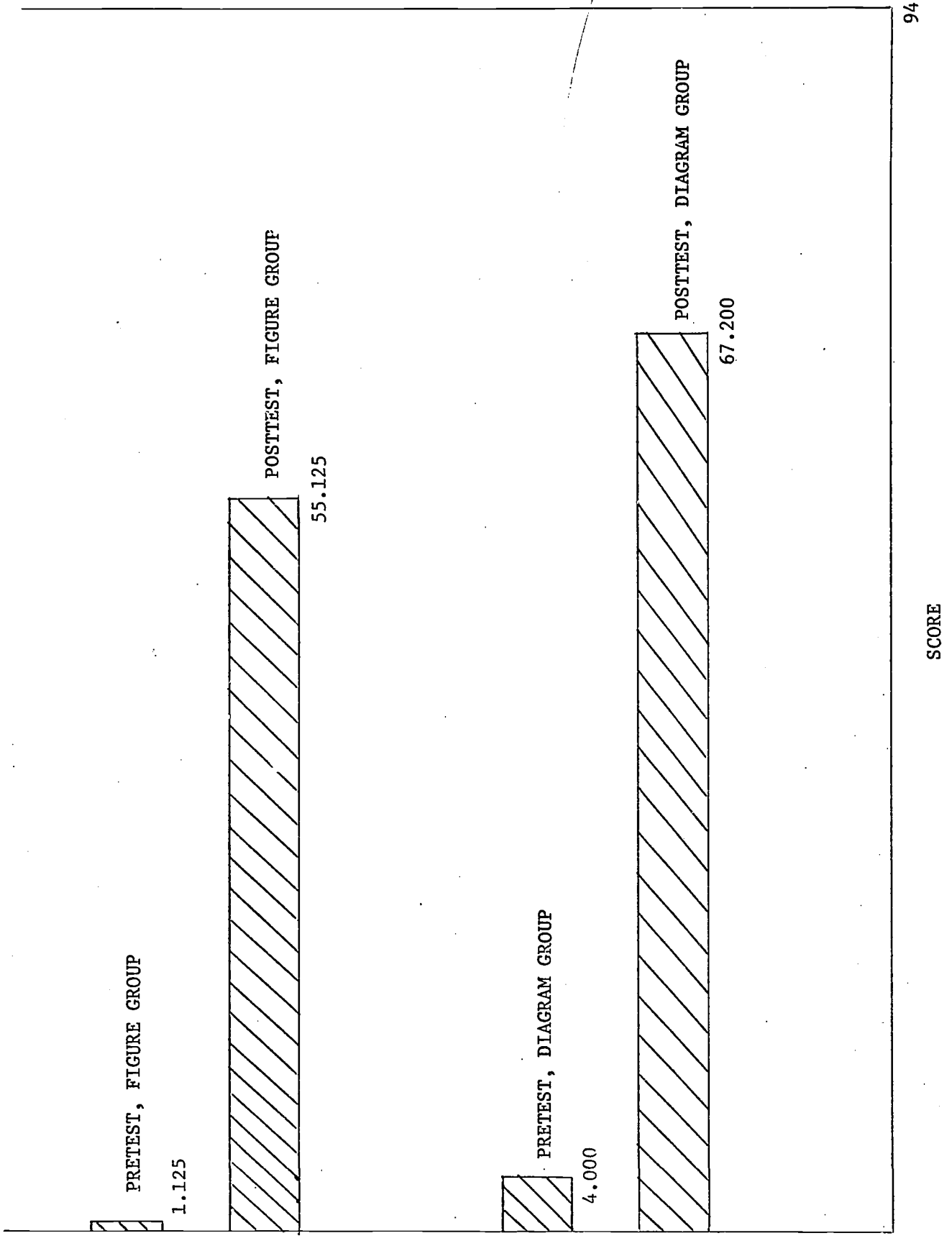

Fig. 15. Diagram group vs. figure group: cognitive learning as reflected by mean pre- and posttest scores.

TABLE 3

Correlations for the PD (Schematic Diagram) Group

N = 10

	1	2	3	4	5	6
1. Cognitive Pretest		.290	-.154	-.183	.013	.684*
2. Cognitive Posttest			.631*	-.680*	.330	.577
3. LAR[a]				-.214	.207	.344
4. Attitude Scale-computers Pretest					-.304	-.504
5. Attitude Scale-computers Posttest						.473
6. Attitude Questionnaire-Course Materials						

[a]Learning Aids Reproduction Test

*$p \leq .05$

TABLE 4

Correlations for PF (Representational Diagram) Group

N = 8

	1	2	3	4	5	6
1. Cognitive Pretest		.119	-.650	.259	.609	.570
2. Cognitive Posttest			.155	-.117	-.332	-.262
3. LAR[a]				-.125	-.277	-.201
4. Attitude Scale- computer Pretest					.156	.251
5. Attitude Scale-computers Posttest						.878*
6. Attitude Questionnaire-Course Materials						

[a]Learning Aids Reproduction Test

*$p < .05$

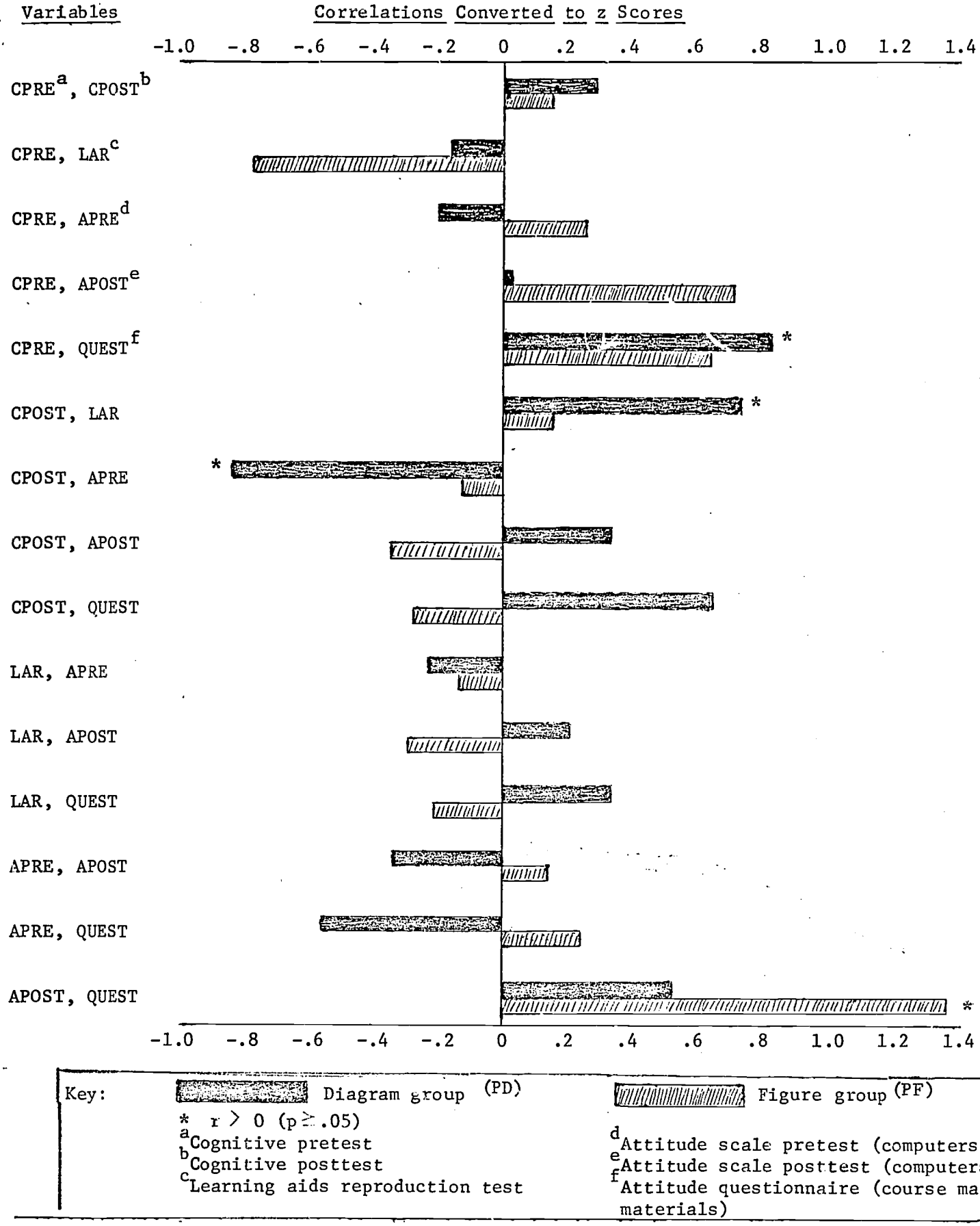

Fig. 16. Correlations for the Diagram and Figure groups.

PD-schematic group data. Three correlations were significant for the PD group which used the schematic diagram:

a. between amount of verbal knowledge (posttest) and (perceptual knowledge) ability to reproduce the learning aid diagram (r = .631)

b. between pretest attitudes toward CAI and the amount of verbal knowledge (cognitive posttest) learned. This was a negative correlation (r = -.680).

c. between what they knew about the course material beforehand and their attitude toward the course materials including the learning aid (r = .684).

These data indicate the following. First, that when the schematic diagram is used during learning, the amount of anatomical information acquired (posttest) is related to the student's ability to reproduce the diagram of the trigeminal nerve, its branches, and to label its parts and regions.

Second, the students who had the most positive attitudes toward computers before taking the program learned least.

Third, the students who knew more to start with had the most positive attitudes toward the way the course was presented to them. In other words, the students who knew the most anatomy when they began appreciated the schematic aid most.

PF group data. There was only one correlation that achieved significance for the PF group. The students with the most positive attitudes toward CAI also had the most positive attitude toward the course materials at the completion of the CAI course.

PD vs. PF groups. The three largest differences in z score transformations of the correlations (see Fig. 16) were:[5]

[5] A difference between z transformations of r's with the size groups used are 1.15 for $z_{.05}$ and 1.50 for $z_{.01}$. These values are based upon H_o: $\rho_1 = \rho_2$ using a two-tailed test.

a. CPOST vs. Quest.;

b. APOST vs. Quest.; and

c. APRE vs. Quest.

These data suggest that the schematic diagram as contrasted with the anatomical figures:

a. produced a positive correlation between amount known after learning and attitude about the course;

b. resulted in a higher positive correlation between attitudes toward computers after learning and attitudes toward the course materials;

c. produced a negative correlation between attitudes about computers before learning and attitudes toward the course materials after using them to learn

Summary

The data from Experiment II confirm those of Experiment I in indicating that students learn verbal and perceptual information about the nervous system when it is presented to them by CAI (see Fig. 15).

Where a schematic is used early in learning the students learn both the spatial relationships and the verbal information. Those who like CAI most to begin with learn least verbal information; those who knew most to begin with had the most positive attitude toward CAI afterward. On the other hand, of those who learn with CAI using the traditional visual aid the ones who like CAI most liked the course most.

Differences in correlations between some of the same pairs of variables were found suggesting that the visual aid that is available during learning alters the relationship between these variables. All of these effects involved attitudes.

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HARVARD CAI LABORATORY: PROGRAM ABSTRACT

Program Name: TRIGEM

Subject Matter: the maxillary division of the trigeminal nerve

Author(s): based on Johnson, R. P. The effect of mnemonic learning aids upon immediate recall of neuroanatomical facts. Master's Thesis, University of Illinois, 1966. Adapted for CAI presentation by S. H. Desch (Harvard CAI Laboratory).

Programmer(s): S. H. Desch

Target Population: first year dental (primarily) and medical students

Length of Program: approximately 1-1/4 hours of student time required

Instructional Logic: tutorial

Instruction Language: CAILAN

Computer: IBM S 360/65, Harvard Computing Center

I/O Devices: IBM 1050 terminal or standard teletype (KSR 33)

Auxiliary Equipment: Representational diagrams or schematic diagrams are given to students before they start the program. They are in a booklet.

Installation(s): Remote terminals at Tufts University Dental School, Medford, Mass., Harvard CAI Laboratory, Cambridge, Mass., and the Harvard Medical School, Boston, Mass.

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